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Guide to the Geology from DAUPHIN to SUNBURY

By

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PLATE 1

Photograph by Geo. H. Ashley.

View north from Fisher Ridge showing island-dotted Susquehanna River.

GUIDE TO THE GEOLOGY FROM DAUPHIN TO SUNBURY

By Bradford Willard

INTRODUCTION

The region described in this guide book lies along the east bank of the Susquehanna River from the city of Sunbury south through the borough of Millersburg, across Peters Mountain to Dauphin a total distance of about 45 miles by road. Most of the phenomena described are to be seen without leaving U. S. Route 15. The tour can be covered leisurely in half a day. The area lies entirely within Northumberland and Dauphin counties, and is embraced in United States Geological Survey topographic maps of the Sunbury, Millersburg and Harrisburg quadrangles. Articles describing the geology of this area, particularly the neighborhood of Harrisburg and Selinsgrove Junction, are listed in the references at the end of this bulletin. This tour is one of a series of Educational Field Trips in Geology sponsored by the Pennsylvania Topographic and Geologic Survey. As it was one of the best attended of these trips, it is believed that a guide book to the area will be acceptable to the public. It ties in with guide books, G 8 and G 12.

In the neighborhood of Selinsgrove Junction and southward, there is a well-known geologic section which has been discussed for many years. Geologically and geographically, it is interesting. The section commences on the Pennsylvania Railroad and U. S. Highway 15, south of Sunbury, and continues south along the east bank of the river through Millersburg, to Dauphin, crossing Peters Mountain via Route 225. The road leaves the river several times and runs over the hills a short distance, only to return again to the river. In the northern end of the section about Selinsgrove Junction, a broad, low anticline brings up the Helderberg and uppermost Silurian limestones and limy shales. A second fold a little farther south brings up only the beds down to, and including, the Oriskany sandstone. At Dalmatia a more pronounced arch brings up yet older beds, thought to belong to the Wills Creek shale of the Silurian system. Conversely, synclines bring down the Catskill red beds of the Devonian south of Fishers Ferry in Little Mountain-Line Mountain "cove." These late Devonian strata again descend at Mahantango Mountain, and here the still higher Pocono of the Lower Mississippian reaches highway level, to be followed by the Mauch Chunk red beds of later Mississippian age at Millersburg. At the southern terminus of the tour, north of Dauphin is another syncline of Mauch Chunk red beds; and Halifax lies near the axis of a broad anticline of Upper Devonian rocks.

PHYSIOGRAPHY AND GLACIAL GEOLOGY

The physiography of the Susquehanna Valley from Sunbury south is of outstanding interest. The entire route lies in the Ridge and Valley Section of the Appalachian Valley Province. At Sunbury the North Branch of the Susquehanna River from the east is in confluence with the West Branch which comes down from the north. The greatest of Pennsylvania's rivers has entrenched itself along its southerly course, and cut many water gaps through one ridge after another of hard sandstone. The concordant tops of these ridges are supposed to reflect an ancient land surface over which the ancestral Susquehanna River once flowed. It will be observed that the "grain" or trend of the underlying rock runs about at right angles to the course of the river. That is to say, the outcrops of the geologic formations composed of rocks of various hardness or solubility trend about east and west, while the river runs from north to south. As the river maintained its ancient, cross-grain course, it was able, because of its size and erosive power, to saw its way down irrespective of the varying resistance of the rocks that it encountered. But its tributaries, being of a less sturdy nature, soon adapted their courses to the lines of least resistance and followed the softer or more soluble east-west bands of rock. Consequently, we find the tributary streams tending to run into the Susquehanna nearly at right angles to the main valley, forming what is called a trellis drainage stream pattern. Between these tributary valleys rise ridges of hard and resistant rocks which have withstood erosion by the smaller water courses, though cut through transversely by the Susquehanna, the master stream of the area.

Although water was the chief modifier of the surface of the land in central Pennsylvania and is responsible for the major physiographic features, another agent has been effective, and has left its traces in the immediate neighborhood of Selinsgrove, Sunbury and Northumberland, though no farther south. This agent was ice. During the Great Ice Age, or Pleistocene, geologists call it, a vast ice sheet shoved south from Canada over eastern North America. In central Pennsylvania it traveled down the Susquehanna Valley as far as Selinsgrove. The precipice known as Shikalemmy cliff opposite Northumberland and Sunbury is supposed to indicate how an ice tongue from the North Branch impinged against the rock and rasped it off vertically. As the cliff is on the *inside* of the river bend, it could not conceivably have been water cut. As ice plowed south about as far as Selinsgrove, we see today in road cuts south from Selinsgrove Junction till desposits, heterogeneous mixtures of boulders, clay, and sand dumped by the ice as it melted away from this point of the Susquehanna Valley. The broad flat area about Selinsgrove Junction is perhaps in part due to the deposition of sand and gravel by streams from the melting ice. As that same ice melted, the river must have been much higher than now. That it was so is proved by the fact that here and there we find patches of water-laid gravels well above our highest flood marks. So excellent a picture has been drawn for this region by Leverett in his recent bulletin (see list of references) that I quote *ad libitum* from him as follows (pp. **24-27**):

"A conspicuous Illinoian ice lobe projected down the valley of North Branch of Susquehanna River from the border of the Wisconsin drift just above Berwick to its junction with West Branch of Susquehanna River at Northumberland. A sublobe there branched off and extended about four miles up West Branch valley, to Winfield. The main lobe continued down the Susquehanna Valley to Selinsgrove, and terminated in a low area west of that village. The length of the lobe as exposed outside the Wisconsin drift border is about 40 miles. Its greatest width is not more than 8 miles. For a few miles west from Berwick it was confined between Nescopeck Mountain on the south and Lee Mountain on the north. It filled lowlands along and near the Susquehanna farther west and probably covered intervening uplands. But its deposits are very scanty on the uplands, and on parts of the lowland, so that the limits of the lobe are hard to define. A few places appear to have been exceptionally favorable for the lodgment of drift, but in general the deposits are very light, and in places the ice appears to have eroded or sculptured the rock surface and left scarcely a trace of drift on it. The deposits are exceptionally heavy in the headwaters of Little Roaring Creek near the highway from Danville to Elysburg 3 to 4 miles south of Susquehanna River, and up to an altitude 500 feet above the river. The occurrence at this altitude seems to necessitate the overriding of lower tracts nearer the river on which the drift deposits are scanty. Below Danville the ice lobe appears to have been much narrower than above that city, and to have had a general width of only about 2 miles, yet it extended 20 miles farther down the valley. At its terminus the lobe covered ground more than 200 feet above the river. But the drift is present on slopes down to within 60 feet of the present river level. There has thus been only a very moderate deepening of the Susquehanna valley since the deposition of the drift.

An instance of oversteepening by glacial erosion may be found in the precipitous bluff opposite Northumberland . . . [Plate 6, *B*], which stands west of the junction of West Branch and North Branch valleys where the ice lobe appears to have split. It rises almost perpendicularly to a height of 400 feet above the river, and that, too, on an inner curve of the stream where deposition rather than cutting should have taken place.

Character of the drift. The Illinoian drift in this lobe is generally of clayey material, with only occasional pockets and beds of sand and gravel. The color is usually reddish, probably mainly because of high oxidation, as there is only a small amount of red rock material in the drift here. The color is decidedly in contrast with the yellowish brown color of the oxidized portion of the Wisconsin drift in neighboring localities.

Topography of the drift. In a few places the Illinoian drift has a hummocky morainic topography, but generally the surface is nearly plane. The most conspicuous display of morainic topography is at the terminus of the lobe, west of Selinsgrove. An area there of three or four square miles has many knolls 10 feet or less in height among which are saucer-like depressions 3 to 5 feet in depth. The Pennsylvania Railroad makes cuts in some of these knolls near Clifford Station to a depth of about 8 feet, or to the level of their base. The drift here carries only small boulders, usually less than a foot in diameter. The limestone pebbles seem to have been completely dissolved as far down as the cuts extend, and many of the crystalline pebbles are in an advanced state of decay. In this respect the Illinoian drift is more strikingly in contrast with the Wisconsin drift than in its topography.

Morainic topography is also displayed in a recess on the east side of the Susquehanna about 3 miles below Sunbury, and up to an altitude about 200 feet above the river. This deposit seems likely to have been brought in by a lateral movement of the ice eastward from the river valley rather than by southwestward movement across a low pass between Little Shamokin Creek and this recess."

STRATIGRAPHY

Beneath the mantle of glacial drift, river alluvium and soil, there is a thick sequence of bedrock formations which has been folded, up-

lifted, and worn down. Today we may study them in many rock cuts and natural outcroppings. These are all assignable to that great rock division, the *sedimentary rocks.* That is to say, they were formed largely as precipitates or from transported fragments of older rocks brought together by various agencies, chiefly water. Many of the sedimentary rocks that we shall see in the trip from Sunbury to Millersburg were deposited in the ocean. That this is true can readily be affirmed by observing the numerous fossil sea shells which they contain. There are, however, a few formations, which we believe were deposited on land or in streams and fresh-water bodies, largely from the fact that they contain the remains of land plants rather than sea shell. The rocks are assigned by geologists to various *systems*, in this case five being represented, Quarternary including the Pleistocene and Recent, Pennsylvanian, Mississippian, Devonian and Silurian. The whole may be presented compactly in table form as follows:

GEOLOGIC COLUMN

	Thickness in feet
QUARTERNARY SYSTEM	
Unconsolidated deposits of varying thicknesses; till, alluvium, river terraces, soil, etc.	
PENNSYLVANIAN SYSTEM	
Pottsville conglomerate. White conglomerate with land plants and coaly layers in Third Mountain.	50+
MISSISSIPPIAN SYSTEM	
Mauch Chunk formation. Red sandstone and shale.	2500(?)
Pocono formation. Gray sandstone and conglomerate, carrying remains of land plants. These hard beds are the chief ridge-forming rocks in the area.	1500+
DEVONIAN SYSTEM	
Catskill facies. Red sandstone and shale with occasional greenish or gray-green sandstones. These beds interfinger with the underlying Chemung or Portage groups, but are themselves nonmarine (fresh-water formed).	2800+
Portage group*	
Trimmers Rock sandstone, gray, hard, fossiliferous.	1000
Brallier and Harrell, greenish and gray sandy shales; fossiliferous in lower part.	150±
Burket black shale, fissile, sparingly fossiliferous.	50+
At the base of the Burket about one foot of limy shale carrries fossils of Tully age.	
Hamilton group	800–900
Mahantango formation, soft, olive to brown shales and thin sandstones; very fossiliferous.	500
These beds may be partly displaced by a massive sandstone, the Montebello.	
Marcellus black shale, locally with large concretions, occasional sandstone members; fossils scarce.	350
Onondaga group	
Selinsgrove limestone, gray, massive to platy; sparingly fossiliferous	75
Needmore (?) shale, ashen-gray; unfossiliferous.	150 (?)

* A little Chemung has been recognized in the basal Catskill near Halifax.

Oriskany group	
Sandstone above, chert below; fossiliferous.	60
Helderberg group	
New Scotland formation, limestone and limy shale, local black shale at top; quite fossiliferous.	60
Coeymans limestone, light gray; fossiliferous.	3–4
SILURIAN SYSTEM	
Keyser formation, limestone and some shale. The limestone tends to be lumpy; fossiliferous.	200
Tonoloway limestone, very thin-bedded limestone dominant; fossils scarce save for swarms of ostracoda.	148+
Wills Creek, greenish to reddish shale	trace

SILURIAN SYSTEM

As noted in the geologic column, the oldest beds to be seen in our section belong to the Silurian system. Of all those that come to the surface, either limestone or limy shale dominate. Thus, at the village of Dalmatia there appears along the main street (on Route 15) immediately south of the "square," a little greenish shale which is supposed to belong to the Wills Creek formation. This is the oldest rock seen on the tour. The overlying beds of the Silurian system are assignable to the Tonoloway and Keyser. They are usually a thin-bedded or lumpy limestone whose commonest fossils are large ostracods. The beds belonging to the Tonoloway are best seen in the northern of the two anticlines at Selinsgrove Junction, and may be visited only by leaving the highway and walking the railway tracks. Strictly speaking, the Tonoloway is not the highest member of the Silurian system, although until very recently such was the usage of stratigraphers in Pennsylvania. Now the tendency is to draw the Siluro-Devonian boundary a little higher so that we are now including the former lowest part of the Helderberg group, the Keyser limestones, in the Silurian. The question is one of the niceties of stratigraphy and applied paleontology and is hardly of importance here. In the geologic column this most recent usage has been adopted, assigning the Keyser to the Silurian, whereas it has until only recently been considered part of the Helderberg group.

For the benefit of any who wish to visit the railroad section at Selinsgrove Junction, the following data on the Helderberg group and the uppermost Silurian are given in a modified and abstract form after the report of J. B. Reeside (see list of references at end of this bulletin):

Reeside (p. 220) prefaces his detailed section with the following statement: "The limestones described by the Second Geological Survey of Pennsylvania as the Lewistown limestone or "Formation No. VI" is exposed along the Northern Central Railway [Pennsylvania Railroad] north of Selinsgrove Junction. Susquehanna River cuts across an anticlinal arch at this point, presenting a section which begins one mile above the railway station and extends approximately 1½ miles toward the north. Both limbs of the anticline were studied,

but only the southern half is described here. The concealed unit forming the center of the arch is probably of Wills Creek age. The succeeding 148 feet of beds contain only *Leperditia,* rare *Rhynchospira,* and *Ectomaria* and have the characteristic lithology of the Maryland Tonoloway, with which they are probably to be correlated. The overlying beds are richly fossiliferous and embrace the Keyser, Coeymans, and New Scotland members of the Helderberg formation. These are succeeded by the Oriskany formation. No indication of the presence of the Becraft member of the Helderberg was seen. The exposures here are excellent and afford the best and most continuous section of these formations observed by the writer."

	Feet
Oriskany group	
Interbedded sandstone, cherty and some shale containing *Anoplotheca flabellites.*	54
Helderberg group	
New Scotland limestone. Limestone, ranging from impure and shaly through limy shale to massive, crystalline, sandy limestone and nodular beds. The middle and lower parts are quite fossiliferous with such forms at *Dalmanella perelegans, Leptæna rhomboidalis, Meristella, Schuchertella woolworthana, Uncinulus nucleolatus, Eatonia medialis, "Spirifer" macropleurus, "S." perlamellosus, Phacops logani,* etc.	57.6
Coeymans limestone. Fairly massive, coarse, blue-gray limestone; sandy to cherty. Fossils include: *Pholidops ovata, Dalmanella perelegans, Strophonella leavenworthana, Gypidula coeymanensis, Atrypa reticularis, Leptæna rhomboidadils, Phacops logani, Schuchertella woolworthana?,* etc.	3.6
Keyser limestone (called Devonian by Reeside). Limestone, variable, from thin-bedded, blue to heavy bedded, crystalline to shaly and nodular beds. In the upper part *Leperditia* occurs. Lower down, fossils are abundant, including *Tentaculites gyrocanthus, Camarotœchia litchfieldensis?, Whitfieldella, Pholidops ovata, Meristella prœnuntia, Schuchertella prolifica, Rensselœria obtusa, R. mutabliis, Pholidops ovata, Uncinulus nucleolatus, U. keyserensis, "Spirifer" vanuxemi* and a number of other forms. The occurrence of *Chonetes jerseyensis* near the middle is of correlative significance.	202.3
Tonoloway limestone. Massive beds occur, but most of this formation is relatively thin-bedded to platy and tends to be impure. A few fossils occur in the upper part, chiefly *Leperditia.*	148.4

DEVONIAN SYSTEM

The Lower Devonian includes the *Helderberg* and *Oriskany groups.* Of the former, no further comment is needed, as it is given above in the description of the beds of the Selinsgrove Junction section. The Oriskany group in Pennsylvania consists of chert, sandstone, and conglomerate and has been divided into two formations, but we need not concern ourselves with further details. The exposures we shall see are mainly coarse sandstone and cherty beds and contain fossils. Among the common forms of the Oriskany are *"Spirifer" arenosus, "S." murchisoni, Rensselaeria* and *Hipparonyx.* Beds of the Oriskany are to be seen sparingly in Fisher Ridge south of Dalmatia and in the Selinsgrove Junction anticlines.

Our Middle Devonian is composed of two groups. The lower, the Onondaga group, is divisible into two parts. Above, the Selinsgrove limestone is found in its type locality at Selinsgrove Junction where it is well exposed in recent highway cuts. It is a dark to light gray, platy to sub-massive, chert-free limestone. Fossils are scarce, but occasionally occur, chiefly *Anoplotheca acutiplicata*. The Selinsgrove limestone may rest directly upon the Oriskany sandstone, or it may be separated therefrom by a gray, ashen, barren shale. This is supposed to be the correlate of the Esopus shale in the east and of the Needmore shale of central and south-central Pennsylvania. However, it is so poorly exposed and so little understood in this region (i.e. Selinsgrove Junction) that little can safely be said about it. At Dalmatia it appears to be absent, as shaly, fossiliferous beds of weathered Selinsgrove limestone rest upon the Oriskany. However, the very fact that these are shaly, may indicate that they are fossiliferous Needmore shale and therefore older than the Selinsgrove limestone proper.

The Selinsgrove limestone is directly overlain by the lowest member of the Hamilton group, the Marcellus black shale. The contact is now probably entirely hidden by slumping, but when the highway across the southern of the two Selinsgrove Junction anticlines was improved a few years ago, it was observed that the base of the Marcellus is made up of a few feet of sooty, black, fossiliferous shale, in disconformable contact with the Selinsgrove limestone. The rest of the Marcellus is chiefly black, fissile shale. Exceptionally, as in the north flank of Fisher Ridge, it carries interbedded sandstone of local importance only. Fossils are rare. At the south end of the long section south of Sunbury, *Liorhynchus limitare, Styliolina fissurella* and a few tiny pelecypods have been found. In this section the Marcellus contains some large, ellipsoidal concretions.

Above, the Marcellus black shale grades into the basal beds of the upper part of the Hamilton, the Mahantango formation. This is dominantly gray to brown shale, non-fissile, but weathering to chips, splinters or pencils. In its lower part in our more southern sections exceptionally a very heavy sandstone dominates the Hamilton in Perry and Dauphin counties. This is the Montebello member. It may be seen in Fisher Ridge, reduced to probably a few tens of feet. It has practically vanished in Hooflander Mountain and is gone south of Sunbury. The Mahantango is very fossiliferous. At the top there almost invariably occurs in eastern and central Pennsylvania a zone with *Vitulina pustulosa* with or without *"Spirifer" tullius*. This occurrence is important as a guide to the highest beds of the Hamilton group. The Montebello sandstone north of Dalmatia yielded the following:

Receptaculites sp.

Newberria sp.
"Spirifer" audaculus
"S." mucronatus
"S" granulosus

Pterinea?

Pleurotomaria sulcomarginata
Loxonema hamiltoniæ
Orthoceras telamon?
O. sp.

"Spirifer" audaculus, "S." granulosus and *P. sulcomarginata* are commonly found associated in this coarse sandstone. In the valley north of Hooflander Mountain, from the soft, upper Mahantango shales were collected:

"Crinoid" columnals	*"Spirifer" mesacostalis*
Philopods?	*Elytha fimbriata*
Leptostrophia perplana	Pelecypod, indet.
Stropheodonta demissa?	*Loxonema hamiltoniæ*
Chonetes lepidus	Gastropod, indet.
Tropidoleptus carinatus	*Tentaculites bellulus*

The Portage group follows the Hamilton with only a very slight break. Until recently the contact was not well understood, and consequently some hesitancy was experienced in drawing the boundary between the Middle and Upper Devonian. Recently, however, overlying the *Vitulina-"Spirifer" tullius* zone at the top of the Hamilton in the valley north of Hooflander Mountain, a limy shale a few inches thick was identified. It carries *Echinocoelia ambocoelioides* and other associated fossils which together indicate that the Tully actually is represented in this part of the Susquehanna Valley. *Hypothyridina* was not found here, but is known from the same zone in Perry County.

The lower part of the Portage consists of shale. Above the thin wedge of Tully is the black Burket shale in Fidlers Run valley southeast from Herndon. It is black and fissile like the Marcellus, and carries *Styliolina fissurella* and a few small pelecypods, among them *Buchiola*. Above the Burket is a few feet of gray, less fissile shale, the Harrell. This carries a Naples fauna. The beds on Fidlers Run yielded:

Ceratopora sp.	*Pterochænia fragilis*
"Crinoid" columnals	*Pelurotomaria?*
Buchiola retrostriata	*Styliolina fissurella*
Paracardium doris	*Probeloceras lutheri*

These beds pass up into more or less greenish, sandy shale thought to represent the Brallier of more western sections. Among these beds, fossils are rather few, but a zone bearing *Reticularia lævis* occurs on Fidlers Run and is correlated with the Losh Run shale of Perry County. This particular fossil is a widespread and excellent guide to the lower Portage in the Susquehanna and Juniata valleys. It appears to tie in with similar zones in New York and Maryland.

The remaining Portage is composed of the hard, flaggy Trimmers Rock sandstone which tends to support low ridges in the central part of the State. The beds are well exposed along Fidlers Run to Herndon and south of Fisher Ridge and at other points. Usually fossils are fairly common. A representative faunule runs as follows:

"Crinoid" columnals	*Atrypa reticularis*
Fenestella sp.	*"Spirifer" mesacostalis*
Leptostrophia perplana var. *nervosa*	*"S." mesastrialis*
Liorhynchus mesacostalis	*"S." mucronatus* var. *posterus*
L. globuliformis	*Athyris spiriferoides*
L. sp.	*Nucula corbuliformis*
	Actinopteria boydi

The Chemung formation is absent in the Selinsgrove Junction or northern part of our tour. The red Catskill comes in directly on top of the Trimmers Rock. However, north of Halifax in the valley of Armstrong Run, a few examples of *Spirifer disjunctus* were collected from the base of the red beds by Wilson Laird, showing that a remnant of the Chemung is actually present. The Catskill continental facies completes the Devonian. It is merely a succession of red sandstone and shale with minor amounts of sediments of other colors. In the southern part of our section on the north flank of Peters Mountain, a heavy greenish to gray-green sandstone, the Honesdale, is interbedded with the red beds and associated with red or pinkish conglomerates. These beds tend to form a bench along the side of this mountain.

MISSISSIPPIAN AND PENNSYLVANIAN SYSTEMS

The Mississippian and Pennsylvanian systems complete the gamut of consolidated rocks of our tour. The Mississippian consists of two divisions. Resting directly upon the red Catskill of the Devonian is the gray Pocono formation. We shall pass several fine sections in these beds of massive sandstone and conglomerate in Peters, Line, Mahantango, Berry, and Little Mountains. In Peters Mountain they contain sufficient coal to have been unsuccessfully mined in the past. The Pocono is succeeded by the red Mauch Chunk shales and sandstones. These relatively soft beds are found underlying the great synclinal valleys at Dauphin and Millersburg. They are of little interest or importance and contain no known fossils in this area. Though not actually exposed along the route, the Pennsylvanian system should be mentioned. Its basal member, the Pottsville conglomerate, is a white to gray rock which forms the crest of Third Mountain near the southern terminus of this excursion. It can be readily studied if one climbs this ridge. Its significance lies in the fact that it is here the western outpost of the Southern Anthracite Field of Pennsylvania.

QUARTERNARY SYSTEM

The unconsolidated deposits of this area need no further elucidation. Those of greatest interest are the glacial sediments between Sunbury and Selinsgrove, and they have been described (page 3) in the quotation from Leverett's recent work.

STRUCTURAL GEOLOGY

We reasonably assume that all of our sedimentary rocks when they were formed as gravel, mud, sand, or ooze on the bottom of the ocean, in lakes or in river valleys, were laid down in horizontal beds or layers. But a glance at the geologic cross-section shows that it is next to impossible today to find a flat-lying bed in the whole sequence! The reason of course is that at some time after the rocks were formed, they were subjected to lateral squeezing and buckled into folds, both big and little. Where the folds are arched up, they become anticlines, and

where they sag down, they are synclines. Sometimes the pressure apparently was too great for the strength of the rock. Then the strata broke, and one part slid over another. Such a movement is called a fault. Disregarding minor flexures, we may enumerate some of the major anticlines and synclines, together with evidence of faulting.

In the section opposite Selinsgrove Junction, the rocks rise in two large anticlines. The southern one is approximately opposite the railroad bridge to Selinsgrove, the northern one about 1½ miles farther north. The northern fold brings the Upper Silurian beds above river level as observable along the railroad. The highway turning east here climbs over this rock roll. The southern fold rises less than the northern. Along the south end of the northern fold there is a fault, for the Oriskany sandstone is partly missing and no beds of the Onondaga group are found to separate the Oriskany from the Marcellus where the road returns to the river south of the fold. A greater anticline is found at Dalmatia. This is like those to the north, but even more pronounced, for it is believed to have raised to the surface the oldest beds in the section. At Halifax a broad, low anticline brings the base of the Catskill red beds up, as may be seen in the valley of Armstrong Creek. Between these anticlines are synclines. The converging crests of Little and Line Mountains simulate the sides of a boat with its prow toward the river. The crests are Pocono sandstone; below on the road we see the red Catskill sandstones and shales, tilted (dipping) south along the north side of the syncline, then dipping north along the south side or limb. Between Dalmatia and Mahantango Creek we pass from the anticline at Dalmatia to the great syncline which continues south beyond Millersburg. This is a very large structure, and is bent down so deeply that not only do the Pocono sandstones and conglomerates reach the road level in Mahantango Mountain, but the still higher Mauch Chunk red beds come down to form the broad valley at Millersburg. The broad valley at Dauphin is another great syncline. Here, the "prow of the boat" is Cove Mountain off to the west in Perry County. This structure is more pronounced than that at Millersburg. Not only does the Mauch Chunk formation come down to road level, but the basal Coal Measures, the Pottsville conglomerate, almost reach that elevation, being present in Third Mountain above Red Hill. In the hills south of Dalmatia, that is, in Fisher Ridge, there is faulting. It will be noted that this ridge near the river becomes double-crested due to a repetition through breaking and slipping over itself of the hard sandstone (the Montebello) found here as part of the Mahantango formation. Other faults may be seen in the much broken and disturbed Pocono in an abandoned quarry and cuts across the end of Mahantango Mountain as the highway swings around that prominence toward Millerstown, and in the Catskill between Fishers Ferry and Herndon.

GEOLOGIC HISTORY

Geologists try to interpret the past events of the earth in what is called Geologic History. We may briefly review the events that have

been instrumental in producing the rocks and structures, the topographic features and present scenery of the section from Sunbury to Dauphin. Long ago, in what geologists call the Paleozoic era, most of Pennsylvania, together with much of eastern North America, was under salt water. The sea was part of a great body that overflowed portions of the interior of the continent and whose areal extent varied during succeeding geologic periods, as the divisions of an era are called. During each of these periods, which are time divisions, there was deposited a system of rocks. According to conditions of shallow or deep water, proximity to or distance from shore, etc., the character of the sediments formed in the sea varied. As our oldest rocks are of the Silurian system, having formed during the Silurian period of the Paleozoic era, we may commence by a recitation of their origin.

The Silurian period was drawing to a close when the Wills Creek, Tonoloway and Keyser formations were laid down. The inland sea appears to have shrunk to a rather restricted area, and an arm extended across Pennsylvania. In it accumulated muds and limy oozes, and in these sediments were buried the remains of the animals which then lived in the sea. Today we recover these as fossil shells. Conditions at the opening of the Devonian were much the same as in the close of the Silurian, for the Helderberg group continues the same sort of rock, limestone and limy shale, as that of the higher Silurian beds. They are distinguished by the kinds of fossils which they contain. About the end of Helderberg time, however, the sea bottom became sandy, and the Oriskany was formed, perhaps in part as beaches along an ancient sea coast which crossed Pennsylvania southeast of our area. The sand was followed by mud and this by the lime of the Onondaga group. The sea grew muddy once more throughout most of the Hamilton time, for the Marcellus and Mahantango formations are dominated by shale which is hardened and consolidated mud. Among the Hamilton sandstones, the chief is the Montebello. They are accounted for as being parts of deltas of rivers which entered the sea to the south and poured their sands out over the old ocean bottom. The Portage formations are much like those of the Hamilton, being shale and sandstone, always with evidence of sea life preserved in their fossils. However, toward the close of Portage time, a change took place. Locally, there is evidence from the fossils that marine life assigned to Chemung time came into the ocean. Elsewhere, these fossils are found throughout thick deposits of sandstone and shale, but here they are known only from the region near Halifax, and there occur at the base of the Catskill red beds.

We spoke of rivers dumping sand into the ocean in Hamilton time. About the close of the Portage, so much sand and mud seems to have come in from the nearby coast that the sea was completely filled. At first there was an alternation of marine and fresh-water sedimentation. The salt-water, gray or green beds of the Portage and the red fresh-water Catskill sediments vied for supremacy. Eventually, the red beds won the argument. Why are they red? It is a long story, and one that is not fully understood even among the best geologists. At least we can say that the red is due to the presence of ferric iron oxide;

iron rust if you like. The succeeding Pocono was laid down in fresh water, but it is not red. Why? The red is due to the presence of ferric iron in the Catskill, where organic remains are few. But organic remains such as plants, even thin coal beds, are fairly common in the Pocono. The carbon is believed to have reduced to a non-red, ferrous state, the iron oxides of the Pocono. Iron may be just as abundant as in the Catskill, but its color does not announce its presence. This is only part of the story, but is a hint at least of the larger explanation. Red beds follow the Pocono again as the Mauch Chunk in which there are practically no fossils. This bears out what we said in the last two or three sentences.

If our section carried us a little farther east, we would find the Coal Measures above the red Mauch Chunk, as non-red, fresh-water-formed strata with abundant plant remains present to reduce the iron oxides and keep them from turning red. But our section normally ends with the Mississippian formations except for the glacial deposits and other unconsolidated materials. We need say no more about the great Ice Age and what marks it has left in the region of Sunbury, or of the river flats, terraces and soil-floored valley and slopes. But these unconsolidated sediments rest upon the folded, hard rocks. The folding must have taken place between the induration of the rocks and the deposition of the unconsolidated sediments.

We have spoken of the sea that overflowed so much of North America, how it filled up and finally vanished. For some unexplained reason, after the sea had filled, the rock layers were squeezed. The sand, mud and gravel of the old sea came from a land to the east and southeast. The folding, looked upon broadly, simulates a great series of billows (rock waves) parallel to the old land and seeming to die away west and northwest therefrom. We believe that the land was pushed northwest and west against the rock mass which was squeezed, arched, folded and faulted under the pressure. Such a disturbance of the earth's crust is called a revolution. Revolutions in geology mark the close of eras. Since this one produced the folds and faults observed in the Appalachian Mountains it is called the Appalachian Revolution. It marked the end of the Paleozoic era in eastern North America.

It is believed that while the Appalachian revolution took a very long time, probably many millions of years, that the folds rose much faster than erosion cut them down. Obviously, for a time the drainage followed the troughs of the synclines, escaping from one syncline to another through low gaps where the anticlines had been uplifted less high or where cross-faulting produced lines of weakness across the anticlines which the drainage rapidly deepened into these valleys. As erosion proceeded, it wore down the surface unequally, depending on the hardness of the rocks and other factors. In time instead of the high-fold ridges came other ridges formed by independent hard layers of sandstone separated by low lands worn out of softer strata between. After a long time the whole region is believed to have worn down nearly to a level plane sloping gently seaward. This has been called the Schooley peneplane. On this plane the streams became established as southeastward flowing drainage, passing indifferently over the hard

and soft strata. Later, uplift began that tilted this plane more steeply seaward. The streams began to flow more rapidly and to deepen their channels into the underlying rocks. As uplift proceeded, the softer rocks were worn down more rapidly than the hard rocks, renewing the topography consisting of ridges of hard rocks separated by valleys of soft rock. With the major streams continuing to deepen their courses across the hard rocks, little by little the minor streams flowing southeastward were beheaded by tributaries of the larger streams eroding back in the shale and limestone belts. Thus in time all this part of the State developed as broad, nearly level-floored valleys separated by narrow, steep-sided mountains. Where the streams held their courses across the hard sandstones, there are water gaps. Where they held their courses for a time and then were beheaded, notches called wind gaps were left in the crest of the mountains. The present level crests of all the mountains of this region are thought to reflect the peneplane that once existed over all of the Appalachian region.

The terraces either side of the river, some of them covered by gravel, represent the more recent stages in the downcutting of the streams. The lower terraces, below the area covered by ice, contain much material washed down from the deposits left by the ice. Some rock even came from as far north as Canada. The lowest terrace, averaging 30 feet above the river, can be traced up to the edge of the last ice sheet at Berwick. The higher terrace, averaging 60 to 80 feet above the river, traces up to the edge of the ice at Selinsgrove. Today of course the rivers and streams are continuing to deepen their channels, but so slowly it is imperceptible.

DETAILED ITINERARY

The following schedule covers the route of this bulletin, starting on Red Hill north of Dauphin and continuing north along the east side of the Susquehana River to Sunbury. Except for about 6½ miles along State Highway 225 between Red Hill and Powell Valley, the tour follows U. S. Route 15. Mileages are recorded from Red Hill northward. It is suggested that those starting from Harrisburg consult this Survey's Bulletin G 8 for a discussion of the geology from Harrisburg to Red Hill. A good road map will be found useful in keeping track of distances.

Miles

0.0 Red Hill, at the brick school 0.9 mile from Dauphin. The crest of Third Mountain northeast of the school is the western terminus of the basal Pennsylvanian rocks, the Pottsville conglomerate of the Southern Anthracite Field. The beds are exposed in an overturned syncline. The white conglomerate overlies the red beds of the Mauch Chunk formation. At the contact is a coarse conglomerate presumably composed of re-worked pebbles from the Mauch Chunk. At this point the physiography is particularly striking. Cove Mountain is observed to swing around to the west, uniting Peters and Second Mountains in a great arc. These even-crested ridges stand out as the trace of an ancient peneplane, while the observer finds himself on a lower level into which Susquehanna River and Clark Creek have entrenched themselves. Water gaps of the river are prominently in view.

The Pottsville conglomerate may be studied by making a short side trip on foot to the crest of Third Mountain. It is the only opportunity on this excursion to see rocks of Pennsylvanian age in place. The structure of the syncline and the character of the rock itself (it is fossiliferous with plant stems, and there are a few old coal workings) are apparent. The vertical bedding of the steep, south limb of the syncline forms a small "rock city." From the brick school, the route goes due north along State Highway 225 across Clark Creek and on toward Peters Mountain in the distance.

0.9 Crossing Clark Creek; note that it is entrenched in the surface upon which we started at the brick school.

1.1 Abandoned quarries east of the road expose the Mauch Chunk red shale and sandstone. Examination of this sequence reveals several minor details such as cross-bedding in the sandstones, inter-bedded fine and coarse sediments, differential weathering of hard and soft beds, rain drop imprints in the shale, mud cracks and ripple marks. The Mauch Chunk underlies the valleys about Third Mountain and extends west to floor Cove Valley across the river in Perry County.

1.9 The road ascends Peters Mountain. This ridge is supported by massive, gray Pocono sandstone and pebble beds, great blocks of which have built a talus slope at the foot of the mountain. The beds are exposed in place in cuts higher up.

3.1 On the north side of the road the rectangle of white fence encloses the mouth of an old mine shaft. At the south side, an abandoned road leads off down the slope toward the east. These are reminders of the days when coal was exploited in the Pocono formation. This coal is said to have occurred in several beds, one at least 4 feet thick, but its quality was too poor to compete with the Pennsylvanian anthracite.

3.3 Crest of Peters Mountain. The cut on the highway gives one a glimpse of Pocono massive to platy sandstone and conglomerate beds. Northward is a superb view of the Susquehanna Valley. Note the even-crested ridges, and the lowlands of soft shale across which the river meanders. By consulting the topographic maps, the several features may be identified. Reference to the geologic sketch map will help orient one's self at this point for the trip northward. The tour continues down grade.

4.1 Hairpin at bench. Note the red soil. It indicates that we have passed out of the Pocono into the underlying Catskill red facies of the Upper Devonian. The bench is supported by the Honesdale gray sandstone and associated beds, a unit interbedded in the red Catskill. As we round the hairpin turn, a large spring (4.2 miles) on the right is approximately on the lower Honesdale contact.

4.4 Down grade still, pink conglomerate and red beds show intermittently to the mountain base. Thence northward through the valley of Powell Creek and the village of Powell Valley, the Catskill is omnipresent.

7.2 Intersection of State Route 225 with U. S. Route 15. Continue north through Halifax. The region is a lowland cut in the soft Catskill red beds. Half Falls Mountain to the northwest is an anticlinal ridge in Middle and Upper Devonian sandstones. The entrenched course of the Susquehanna River skirts the mountain's nose.

8.8 Continuing north from Halifax, we are still in the red Catskill, but, in the valley of Armstrong Creek one Chemung fossil *("Spirifer" disjunctus)* has been found, indicating the age of the lower part of the red beds here. Half Falls Mountain anticline is responsible for the rise of the beds to the surface here. At 9.6 miles the marker of Fort Halifax of the French and Indian War is on the west side of the road.

13.4 At the end of Berry Mountain the contact between the red Catskill and the gray Pocono is uncovered.

13.4–14.0 Cuts expose the Pocono sandstone and pebble beds. These are equal to those that were seen in Peters Mountain and once were continuous across the interval between Peters and Berry mountains. We may project them in imagination as a great arch up into the air and down again.

14.3 At the west side of the road the large spring marks approximately the Pocono-Mauch Chunk contact. We are now about to pass north through Millersburg (15.1 miles), which is in another great synclinal valley like that at Red Hill, but the Coal Measures do not extend so far west here as they do to the south.

15.9–17.0 North of Millersburg cuts and abandoned quarries show the monotonous red sequence of the thick Mauch Chunk formation.

17.4 Passing the end of Mahantango Mountain, the Pocono again is exposed. This time it is rising, having passed under the Millersburg syncline to the south, where it rose in Berry Mountain. At the mountain end, here, is a cut and abandoned quarry. The structure is quite complicated, and both faulting and folding may be observed by standing back a little way and looking up at the rocks. (Try to trace a single bed across the quarry face and see what happens to it!) North of the quarry in the Pocono is a bed of matted, carbonaceous plant stems.

19.3 Passing beyond the mountain, a large quarry east of the road is mostly in talus from the Pocono, but some red beds in place show that once more we have dropped down into the Catskill facies and are about to cross another Catskill lowland.

21.2–21.3 Cuts and another abandoned quarry expose the red beds of the lower Catskill with considerable interbedded, non-red strata as the sequence passes down into the marine Portage sandstones of the Upper Devonian. The approximate base of the red beds is crossed at Mahantango Creek (21.7 miles).

22.1–22.2 East of the road, cuts and old quarries expose the fossiliferous, marine Trimmers Rock sandstone of the Portage group. The road now commences to climb over Fisher Ridge, which is supported by the Montebello sandstone of the Hamilton group. At 22.6 miles is a secondary road west down a steep grade and leading to a large quarry in these beds.

23.3 Sharp turn north. Cuts show the Montebello sandstone, which supports Fisher Ridge.

23.4 Cuts expose the lower Mahantango splintery shales which are non-fissile. These lie between the two crests of Fisher Ridge. Both crests are in the Montebello sandstone. A fault has caused the repetition. The second ridge is northwest of the road beyond the shales just mentioned. The second occurrence of the Montebello pinches out rapidly eastward so that we fail to see it on the highway.

24.5 Cuts expose the black, fissile Marcellus shale at the east side of the road.

24.7 Starting down grade on the north side of Fisher Ridge toward Dalmatia; to the north the river valley opens before us. The many islands suggest a braided stream. On the west the small subsidiary ridge on the north flank of Fisher Ridge is composed of Oriskany sandstone of the Lower Devonian. Cuts on the right side of the road expose more of the Marcellus black shale, here interrupted by a heavy, brown sandstone. This is a local feature, and will be observed not to occur in the Marcellus exposed south of Sunbury.

25.0 The road dips into a small valley and rises over a little ridge with cuts on both sides. We are on the south limb of the Dalmatia anticline. The sequence here is as follows: At the south end the Onondaga limestone and shale appear as olive-drab, punky beds, but fossiliferous. Beneath them (northward) is the Oriskany sandstone and chert which is fossiliferous. At the north end of the cut is the Helderberg limestone. This limestone has been quarried and burned a few hundred yards east along the ridge. As the road drops down into Dalmatia, a fine view opens north up the valley.

25.5 Dalmatia. In the center of the village, on the west side of the road, a small cut exposes greenish shales of Silurian age and thought to represent the Wills Creek formation. They are the oldest beds we shall see on this trip.

25.9 At the north edge of Dalmatia, east of the road, an abandoned quarry marks where the Helderberg limestone was once quarried. This is the north limb of the Dalmatia anticline.

26.3 Passing the end of Hooflander Mountain, the Montebello sandstone appears again in cuts. It has passed "up in the air" above us, in imagination, and come down again here since we last saw it in Fisher Ridge. It is thinning rapidly north, and will not again be recognized surely beyond this mountain, for the Hamilton group becomes practically all shale.

28.1–30.4 Eastward from the river along the valley parallel to the north slope of Hooflander Mountain, many exposures show the Mahantango shales of the Hamilton group. These particular exposures are among the higher beds of the formation, and are very fossiliferous, but weather to such small pieces that collecting is rather disappointing.

30.4–30.7 Hairpin turn northwestward into the valley of Fidlers Run. At this point a section of unusual interest, particularly for those versed in Middle-Upper Devonian stratigraphic fine points, is exposed. Along the road parallel to Hooflander Mountain the highest Hamilton beds exposed carry *Vitulina pustulosa,* whose presence marks the uppermost few feet of these beds. On the road, at the inside of the hairpin turn, a tiny exposure of somewhat limy shale carries Tully fossils and marks the base of the Upper Devonian. Swinging around the turn, the secondary road behind the farm house and barn is cut in the Burket ("Genesee") fissile black shale, carrying a few, minute fossils. Continuing along Fidlers Run in a westerly direction, the Burket is capped by non-fissile, dark shale with a Naples fauna. This is the Harrell shale of the lower Portage group. Above it come greenish, sandy shales correlated with the Brallier of the Allegheny Front far to our west. Among these *Reticularia lævis* marks a key zone. This fossil occurs all through the Susquehanna and Juniata Valleys and marks the position of the Losh Run shale of Perry County. Above this zone the Trimmers Rock sandstone dominates the remainder of the Portage group.

30.7–31.9 Proceeding down Fidlers Run toward Herndon, the Trimmers Rock sandstone shows in a number of cuts and cliffs along the brookside. As the Montebello sandstone dies out northward, the Trimmers Rock takes its place as the principal ridge-forming element among the Devonian formations. It is fossiliferous and passes upward by a transition into the Catskill continental facies.

32.9–33.5 Passing through Herndon, cuts north of the town expose unconsolidated sediments, chiefly cross-bedded sands, which probably represent Pleistocene outwash from the ice sheet some miles ahead. North of us looms Line Mountain which, with co-joined Little Mountain beyond, forms another of those great synclines of Pocono sandstone.

33.8 Crossing a single-track railroad, a deep rock cut on the line east of the road exposes a fine bedding surface of the Catskill red rocks.

34.8–35.3 Crossing Line Mountain. The Pocono fails to come down to road level, and the long sequence of cuts exposes only Catskill. As there is ample parking space on the west side of the road, this is an excellent locality at which to pause and observe the Catskill. Here we may see interbedded sandstone and shale. Mostly red, there are also brown and green and gray beds. The upturned rocks of the south limb of the syncline show faulting with slickensided surfaces where the adjacent beds have slipped over one another. Note the cross-bedded sands, the sheared, weak shale between massive sandstones, and slippage along the bedding surfaces. Where the massive beds are sheared, calcite fills the cracks as gash veins.

36.7 The lowest Catskill here exposed is passed in the north limb of the Line-Little Mountain syncline in a cut to the east of the highway. We continue north through Fishers Ferry (37.3 miles).

37.6 At the mouth of Hallowing Run a cut exposes the Trimmers Rock sandstone of the Portage group. These beds also show in cliffs along the stream to the east. We are passing steadily down in the section as we approach the region of Selinsgrove Junction.

38.2 Cuts west of the road expose part of the lower Portage shales similar to those seen on Fidlers Run.

38.6 The road climbs northward from the first fork north of Hallowing Run.

39.2 Cuts expose shale and thin sandstones of the upper Hamilton. They are fossiliferous, and the sandy beds may be the "fag end" of the Montebello sandstone we saw in Fisher Ridge. At the top (39.2 miles) there is a deep cut. The material here is unconsolidated till, the southernmost expression of the Pleistocene glacier in the Susquehanna Valley. It consists of sticky, yellow-brown clay through which are scattered several rough, angular fragments of rock of several kinds. Farther north in this same cut, underneath the till, the black Marcellus shale is exhibited.

39.4–39.5 After crossing a gully (39.3 miles) the Marcellus black, fissile shale and more till are seen in cuts.

39.7 The Onondaga group comes up here as the Selinsgrove limestone (this is the type region for the unit) is exposed in the south limb of the southern of the two Selinsgrove Junction anticlines.

39.9 Opposite the railroad bridge crossing the river to Selinsgrove, fine cuts along the east side of the road show the sparingly fossiliferous, submassive, light-gray Selinsgrove limestone overlain by the black Marcellus shale. The relations are clear. Down river below the bridge, the Oriskany sandstone forms ledges which are to be seen at comparatively low water. Between it and the Selinsgrove limestone is an interval occupied by ashen gray shale—formerly called Esopus, but now Needmore. This varies greatly in thickness and may be locally absent. Like the Esopus to the east, fossils are few or absent. Looking north from this point, the farthest ridge to be seen in clear weather represents the Lower Silurian. The intervening country is floored by Devonian and Middle and Upper Silurian, relatively soft formations.

40.9 Here, as the road turns northeast, cuts on the east expose the Marcellus black shale or lower Mahantango dark shale. As we continue up the road, the cherty Oriskany comes up in the gutters. Nothing is here seen of the Selinsgrove limestone or the Needmore shale. The presumption is that they have been faulted out. One may leave the road here and walk up the railroad section if he is interested in observing the sequence of Lower Devonian

and highest Silurian beds made famous by the researches of I. C. White, J. B. Reeside and F. M. Swartz. The road continues to climb and swings north across the top of a low ridge. This is an anticlinal structure and is, in fact, the northern and geologically more important of the two Selinsgrove anticlines (see section, Plate 7). The road drops dow nthe north flank toward Sunbury.

43.6–44.2 Long cuts parallel to the railroad and highway expose the Marcellus black shale in what is perhaps the finest showing of this formation in Pennsylvania, at least insofar as completeness is concerned. The lower part only is hidden. The beds contain several zones of large, ellipsoidal concretions. Fossils are very scarce, but a few have been found at the southern end of this cut. Note the absence of any prominent sandstones such as were seen in Fisher Ridge. The rock displays splendid joint systems and a sub-conchoidal fracture. From the southern end of this cut it is possible to visit the section across the Selinsgrove northern anticline. The published accounts should be consulted for details.

44.2 Beyond the north end of the cut in the Marcellus, the road crosses Shamokin Creek and the railroad. A large abandoned quarry, east at this point, is in the lower part of the Mahantango shales which overlie the Marcellus black shales. Fossils are few. This formation gives rise to steep bluffs east along Shamokin Creek.

45.0–45.8 Continuing north along the river front of Sunbury, cliffs across the river expose the Portage sandstones which, near the end of the Reading Railway bridge, pass up into the Catskill red facies with perhaps a thin wedge of interbedded, marine, fossiliferous Chemung. The section ends at the corner of South Front and Market Streets, Sunbury, but it is instructive to continue a few blocks north to see Shikalemmy Cliff, across the river, cut by the ice in beds of the Catskill facies. See the body of this report for Leverett's quoted account of the Pleistocene history of this area.

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Photograph by Geo. H. Ashley

A. **Pottsville conglomerate exposed at crest of Third Mountain.**

Photograph by Bradford Willard

B. **Cut south of Dalmatia exposing beds belonging to the Helderberg, Oriskany and Onondaga groups.**

Photograph by Bradford Willard

A. Cut south of Selinsgrove Junction where the Pleistocene till overlies the Marcellus black shale.

Photograph by Geo. H. Ashley

B. Cut in Pleistocene till south of Selinsgrove Junction.

PLATE 4

Photograph by Bradford Willard

A. Along the highway south of Selinsgrove Junction railroad bridge.

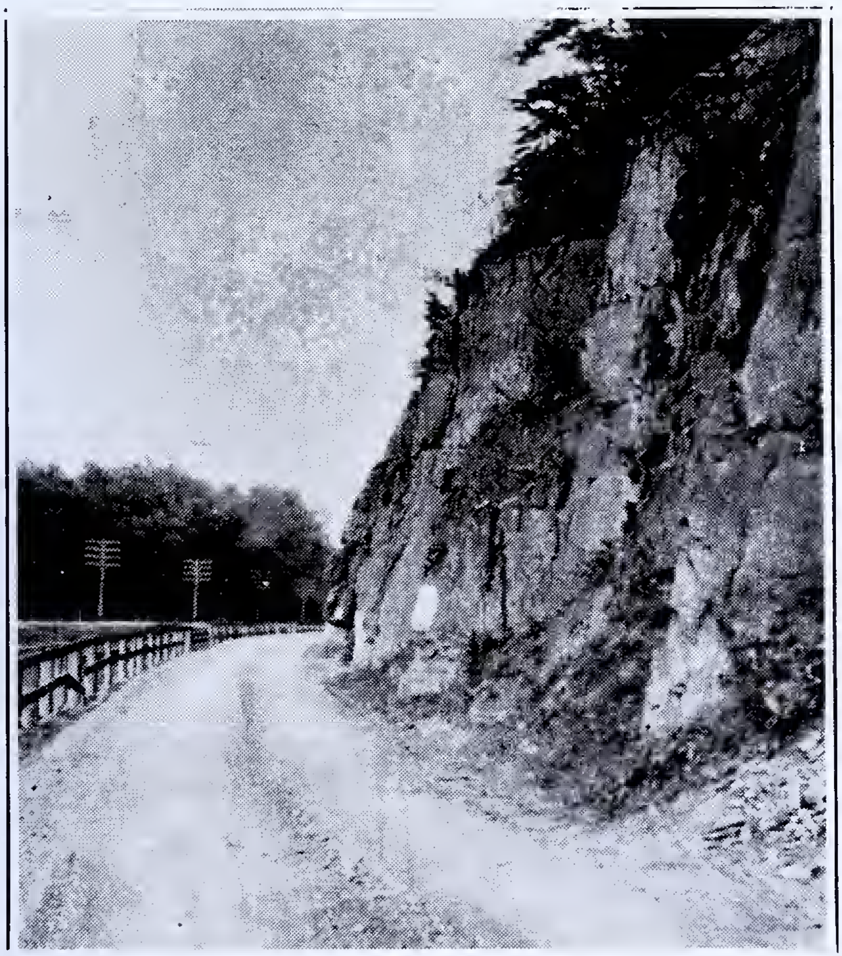
Cuts show Pleistocene till overlying the Selinsgrove limestone of the Onondaga group.

Photograph by Bradford Willard

B. Contact (at automobile) of the Marcellus black shale with the underlying Selinsgrove (Onondaga) limestone at Selinsgrove Junction.

Photograph by Bradford Willard

A. Oriskany sandstone ledges exposed at low water in the Susquehanna below Selinsgrove Junction railroad bridge.



Photograph by Bradford Willard

B. Jointing and shearing in Marcellus black shale along highway south of Sunbury.

This picture was taken prior to the widening of the road.

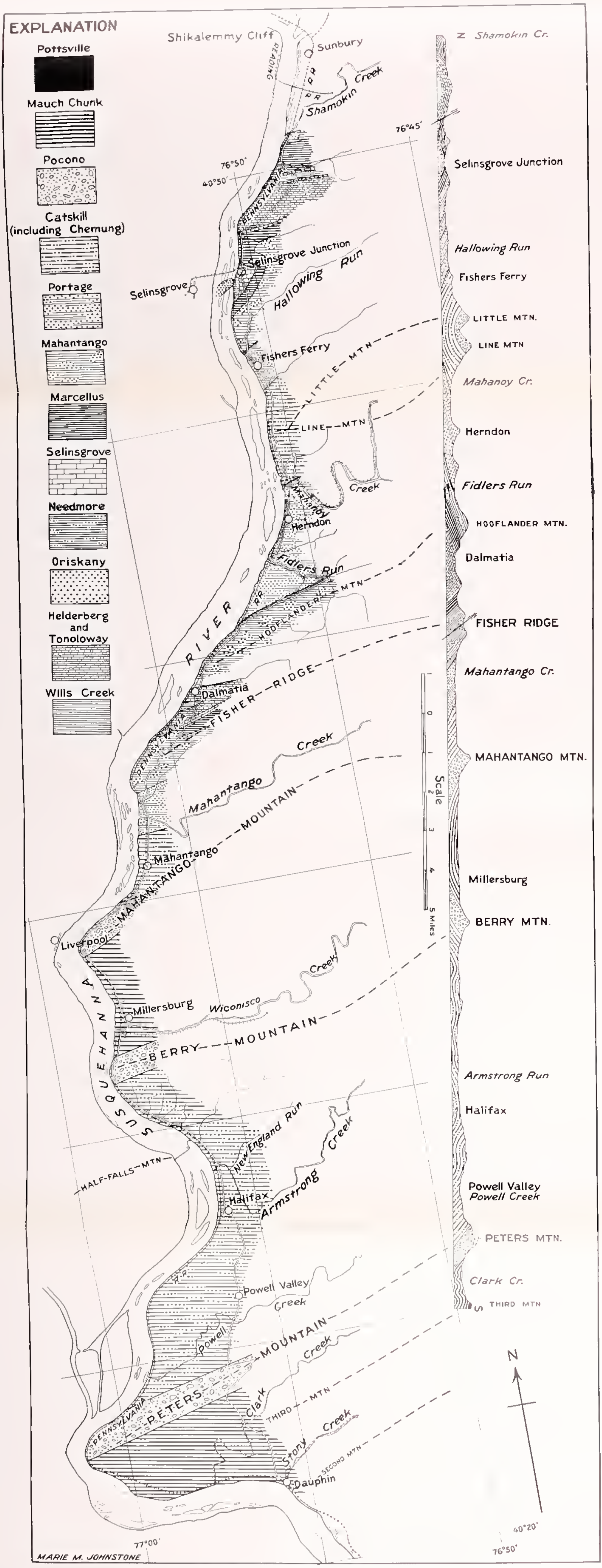
Photograph by Bradford Willard

A. **Concretions in the Marcellus black shale along the highway south of Sunbury.**

Photograph by Geo. H. Ashley

B. **Shikalemmy cliff opposite Sunbury.**

At the confluence of the North and West Branches of the Susquehanna River. The bedrock is Upper Devonian in age, and has been cut back into its present precipitous form by impinging Pleistocene ice.



Geologic sketch map and north-south section along the route between Dauphin and Sunbury.